Electron-Ion Collider Users' Meeting
Stony Brook University 24-27 June 2014

Thomas Burton

Charged-current DIS on Longitudinally Polarised Nucleons at an **EIC**

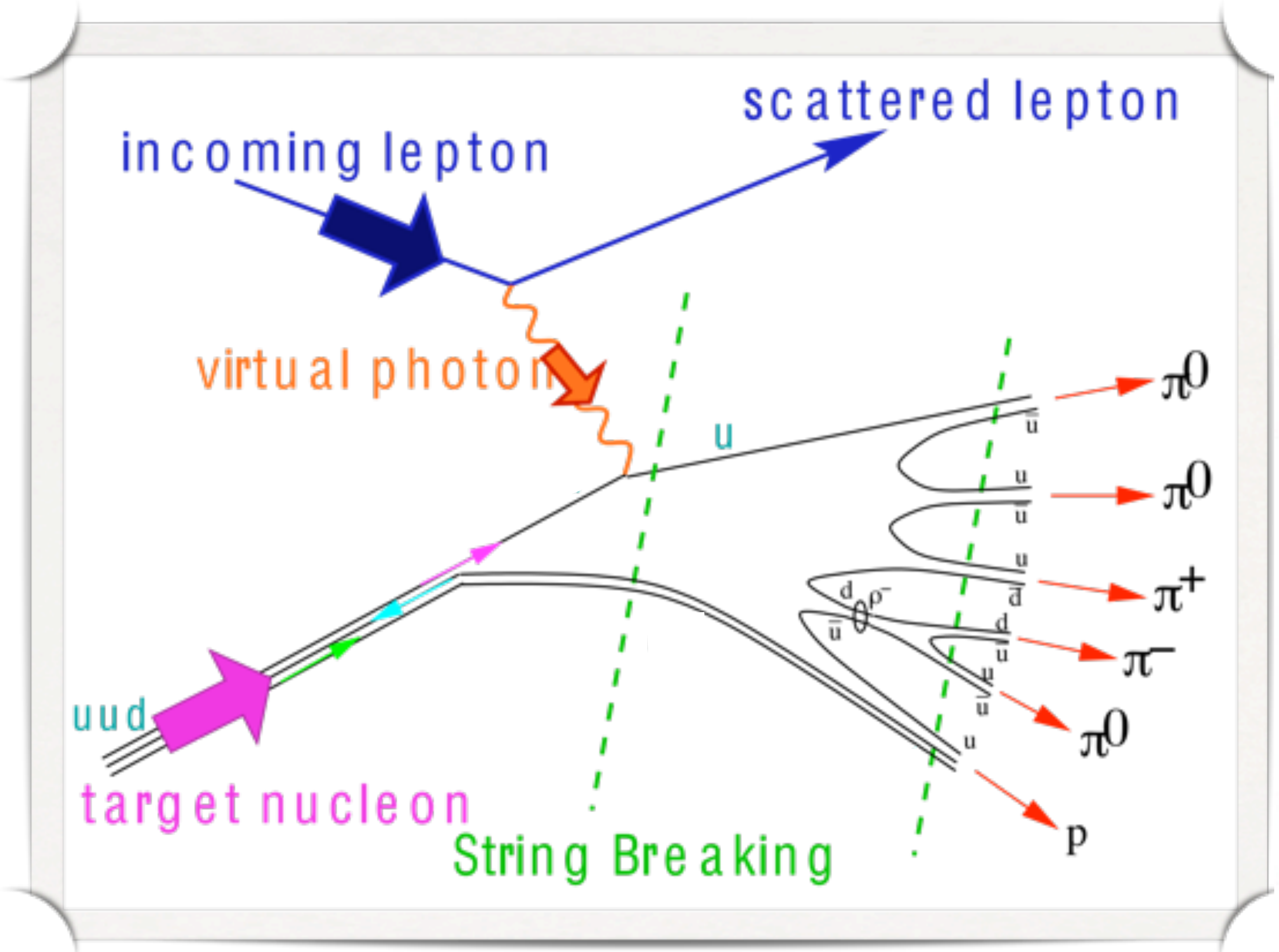
- Charged current DIS with polarised nucleons
- CC DIS at an electron-ion collider (EIC)
- Event simulation with radiative corrections
- Detector effects and kinematic reconstruction
- Asymmetry results

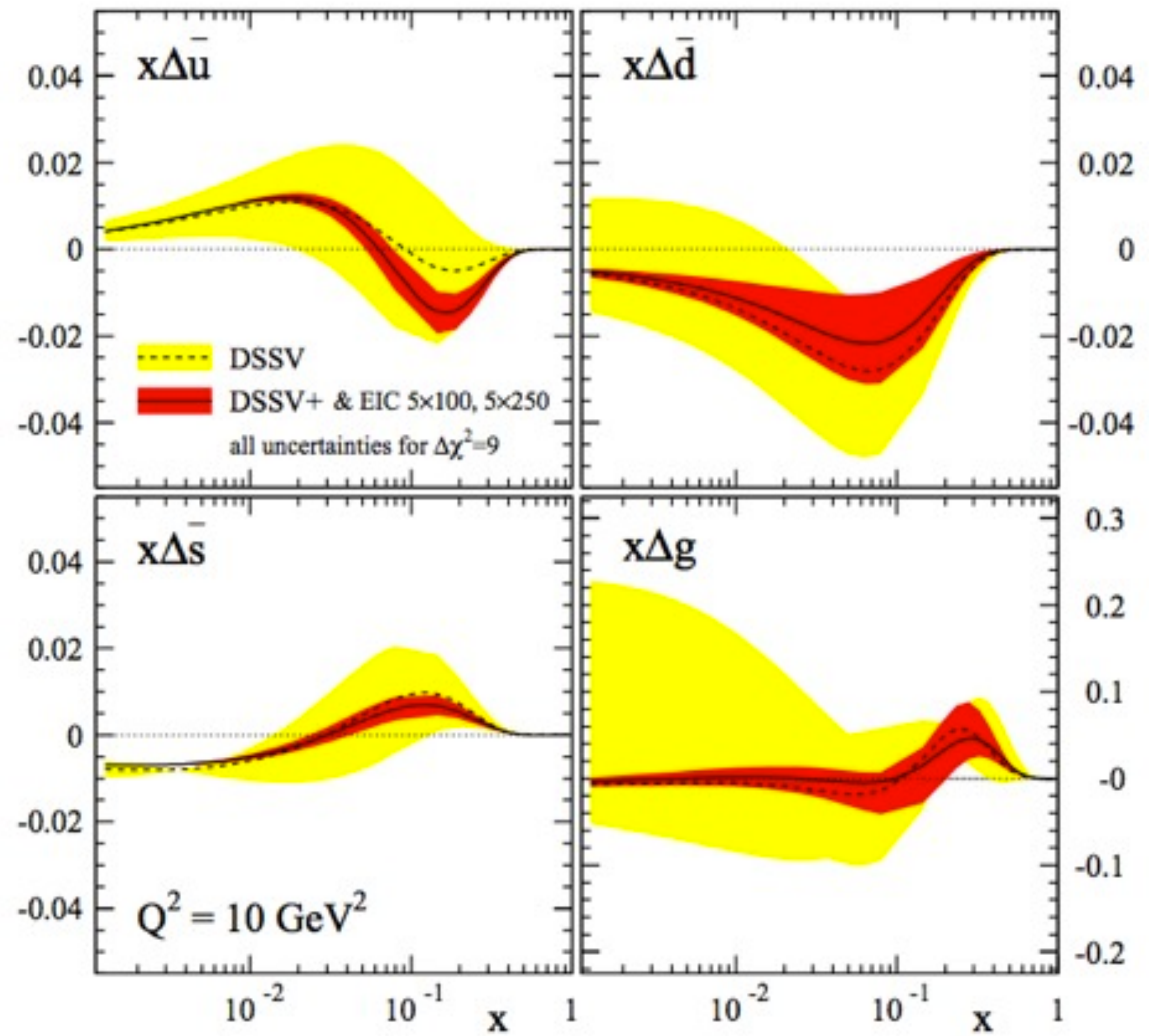
PHYSICAL REVIEW D **88**, 114025 (2013)

Prospects for charged current deep-inelastic scattering off polarized nucleons at a future electron-ion collider

BROOKHAVEN NATIONAL LABORATORY

SIDIS vs. charged current DIS

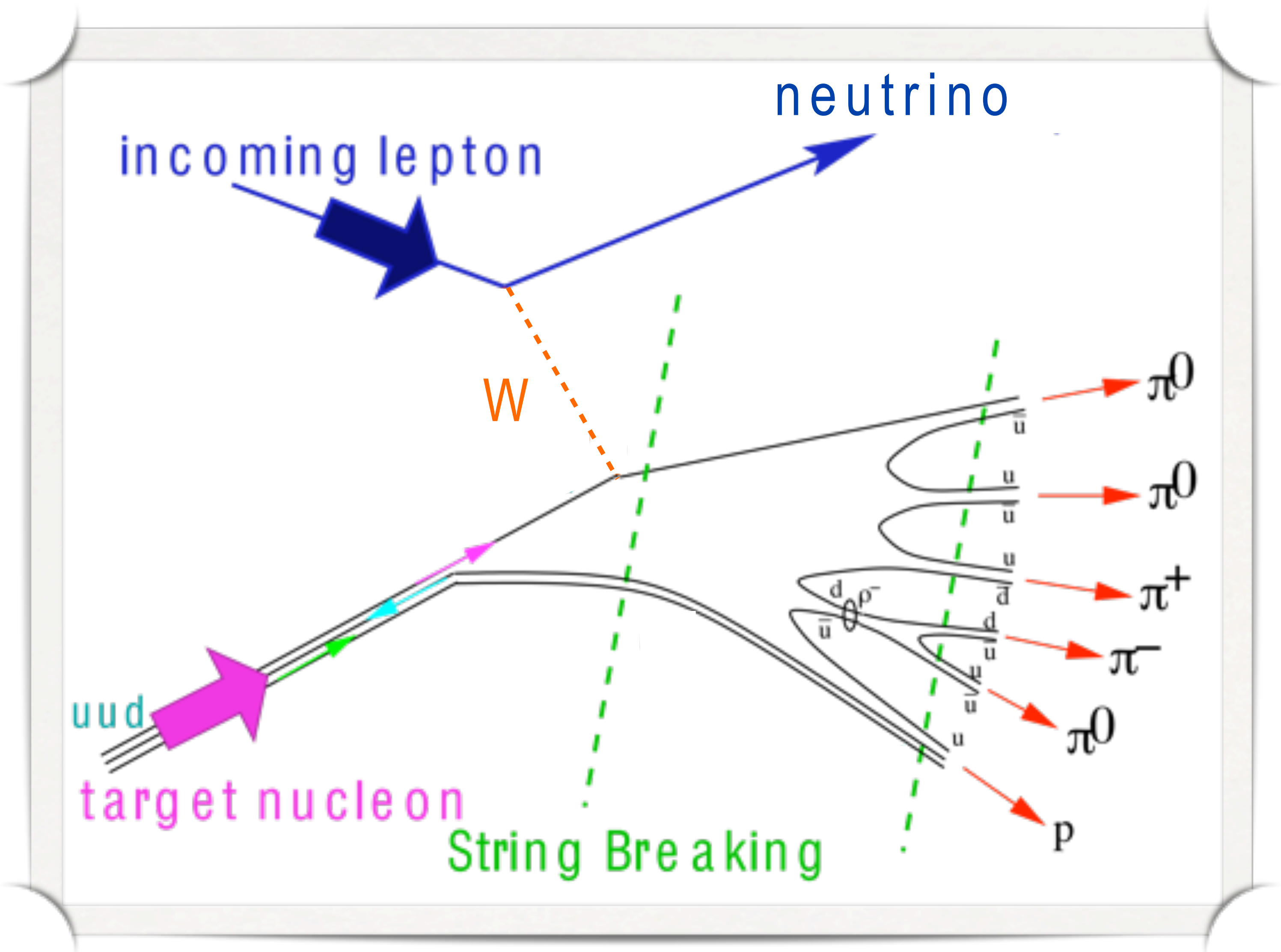




EIC has huge potential for (SI)DIS

- great ability to measure sea quarks
- http://arxiv.org/pdf/1206.6014v1.pdf

SIDIS vs. charged current DIS



- Both allow **flavour separation**
- CC differs in:
  - no **fragmentation functions**
  - accesses higher Q^2
  - different flavour combinations

Want to do both because they
- offer **complementary information**
- access different **kinematic regimes**

Structure functions

$$\frac{d^2\Delta\sigma^{W^-,N}}{dxdy} = \frac{2\pi\alpha_{em}^2}{xyQ^2}\eta[2Y_- x g_1^{W^-,N} - Y_+ g_4^{W^-,N} + y^2 g_L^{W^-,N}]$$

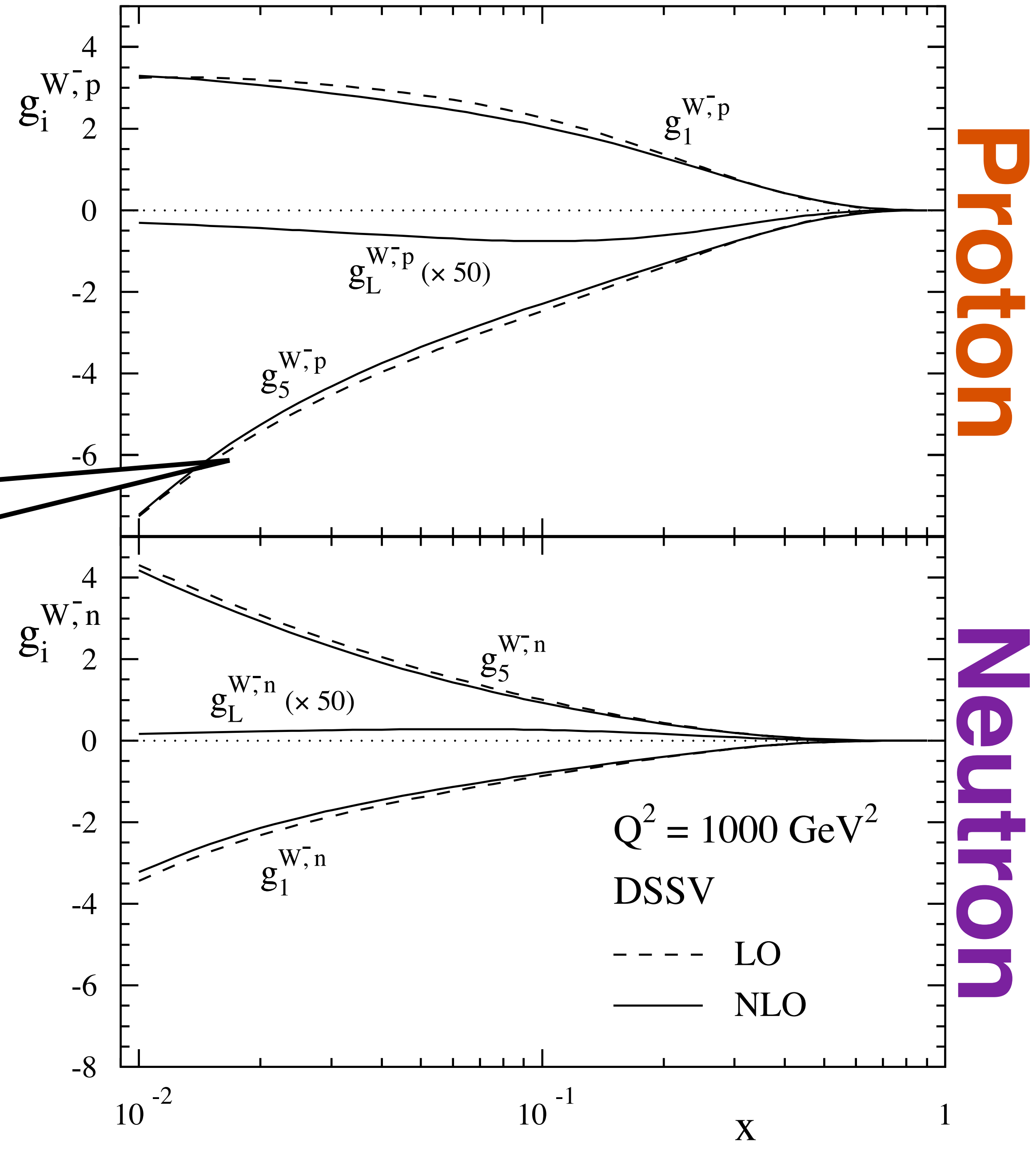
$$g_L \equiv g_4 - 2xg_5$$

CC structure functions

$$g_1^{W^-,p}(x) = \Delta u(x) + \Delta\bar{d}(x) + \Delta c(x) + \Delta\bar{s}(x),$$

$$g_5^{W^-,p}(x) = -\Delta u(x) + \Delta\bar{d}(x) - \Delta c(x) + \Delta\bar{s}(x)$$

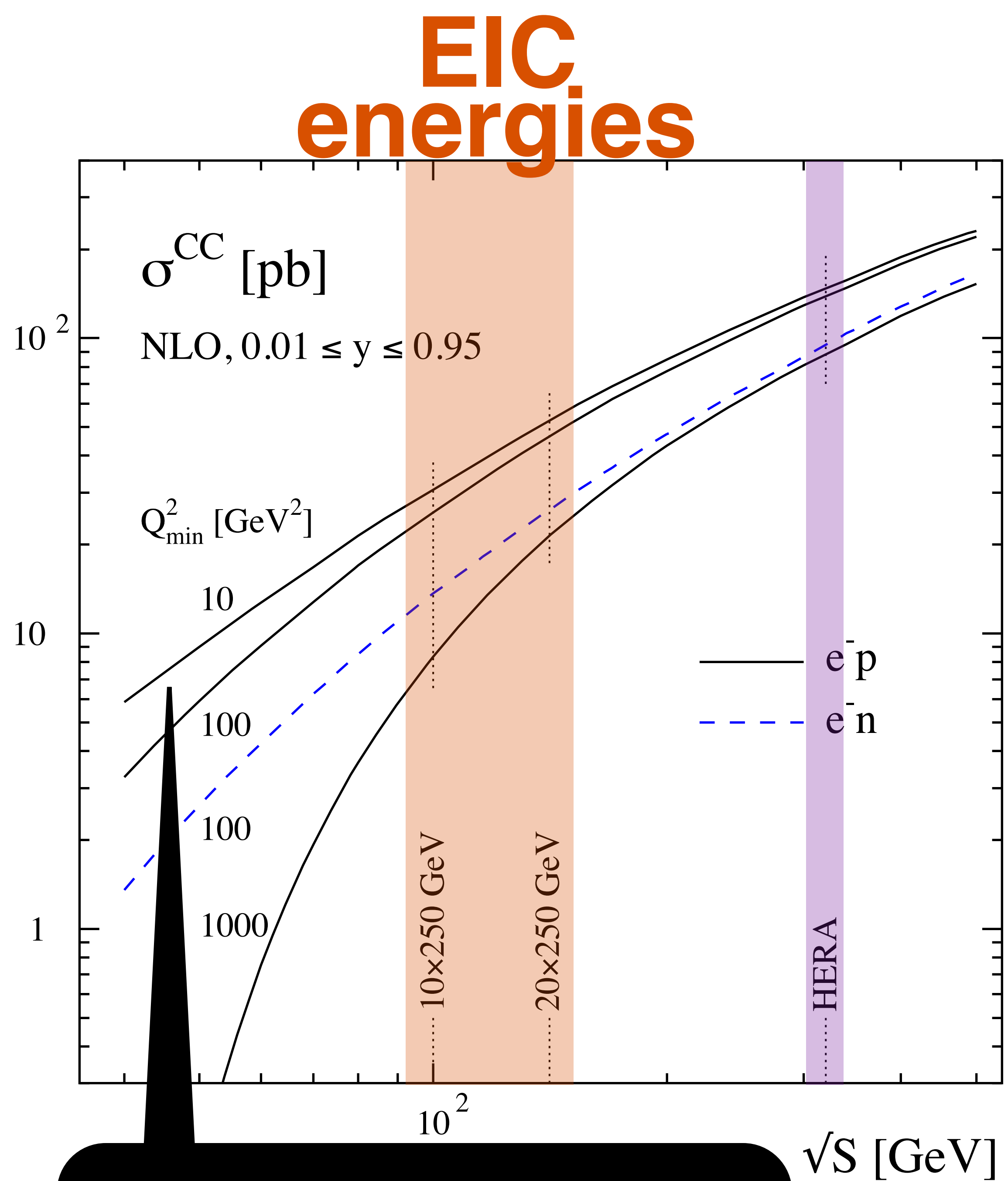
NLO corrections are modest



- How can we measure **polarised CC DIS**?
  - need a **new machine**

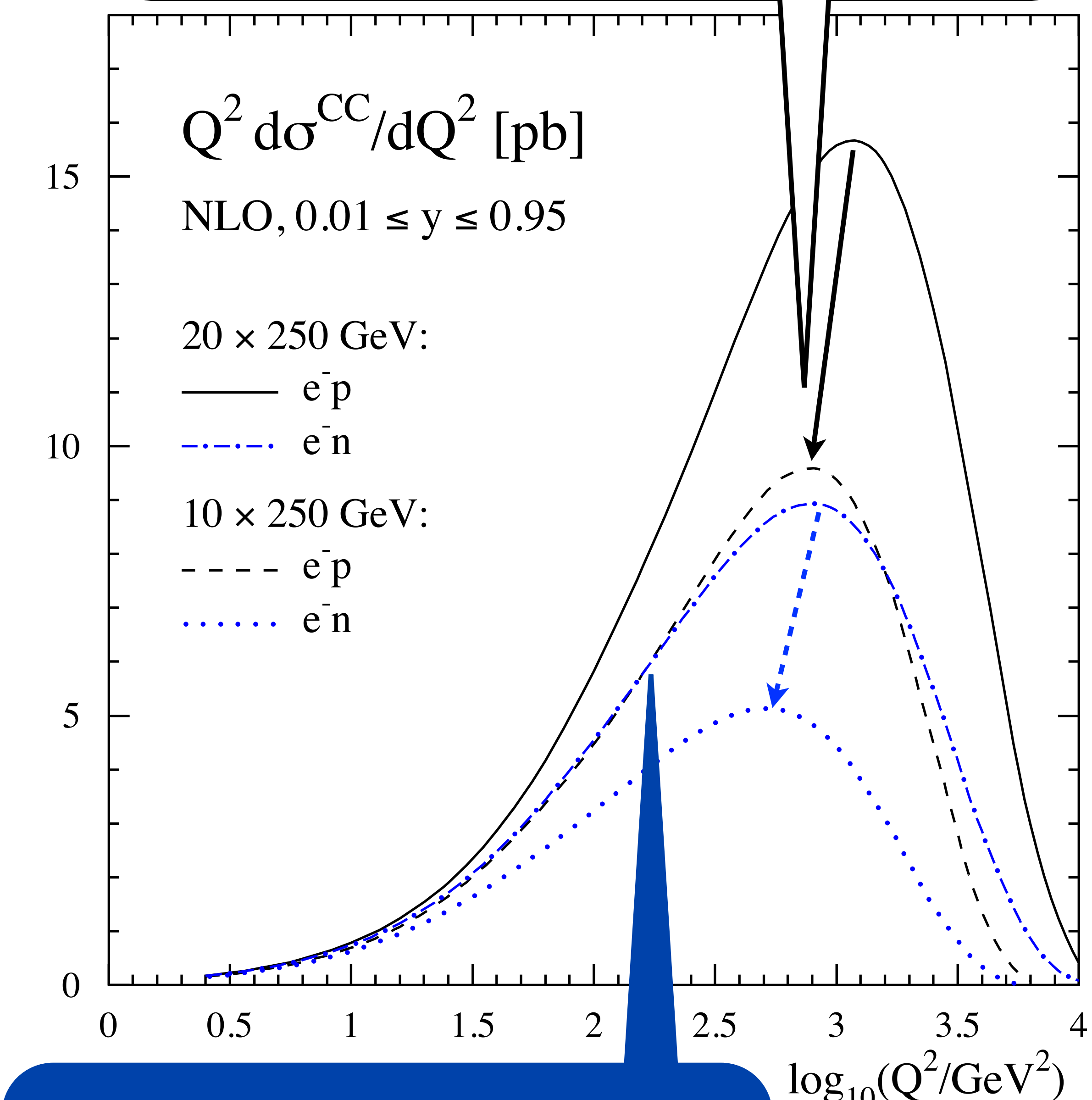
Charged current DIS at an EIC

CC DIS cross section



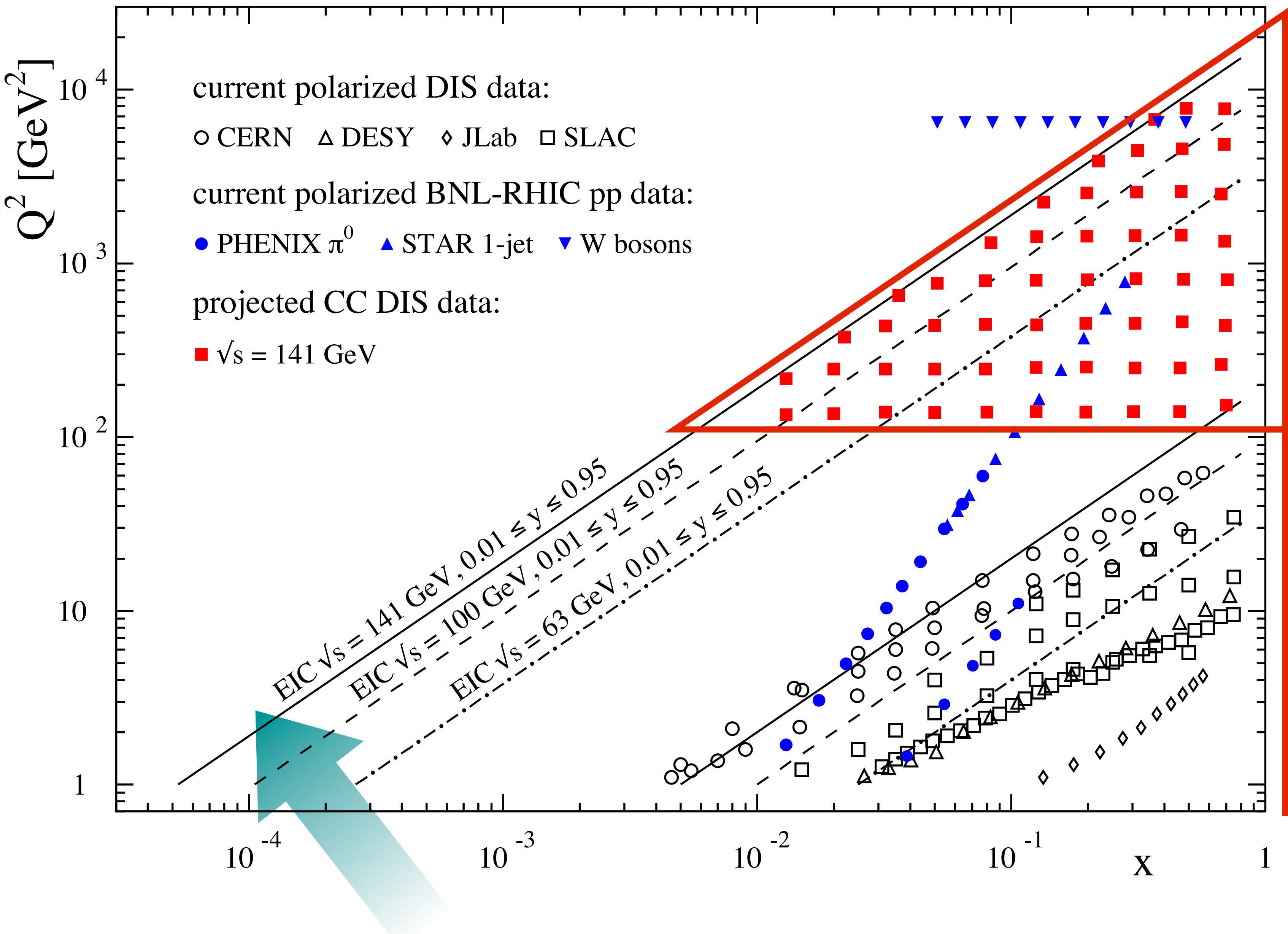
σ depends little on Q^2_{min} for $Q^2_{min} < M_W^2$

Still feasible at lower electron energy



n ~ 2x lower than p
$u(x) < d(x)$

Kinematic coverage



Up to x**100** range in Q^2 at given x

→ **QCD evolution**

Most σ > 100 GeV^2

Limit ourselves to here for this study

Higher energy better for ✓cross section and

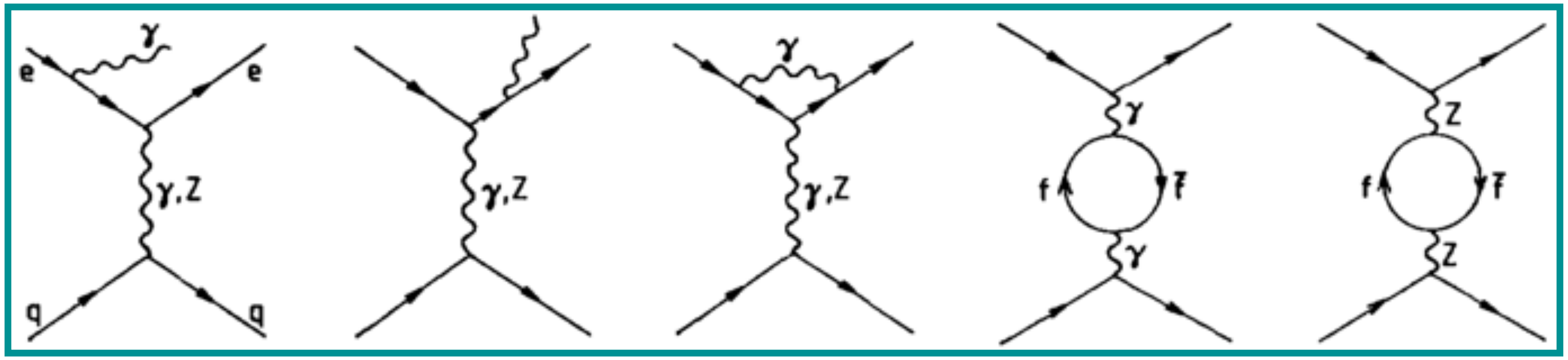
✓kinematic reach

Event simulation with radiative corrections

DJANGOH

K. Charchula, G. A. Schuler, and H. Spiesberger, Comput. Phys. Commun. 81, 381 (1994).

- DIS event generator
  - includes QED and QCD **radiative effects**



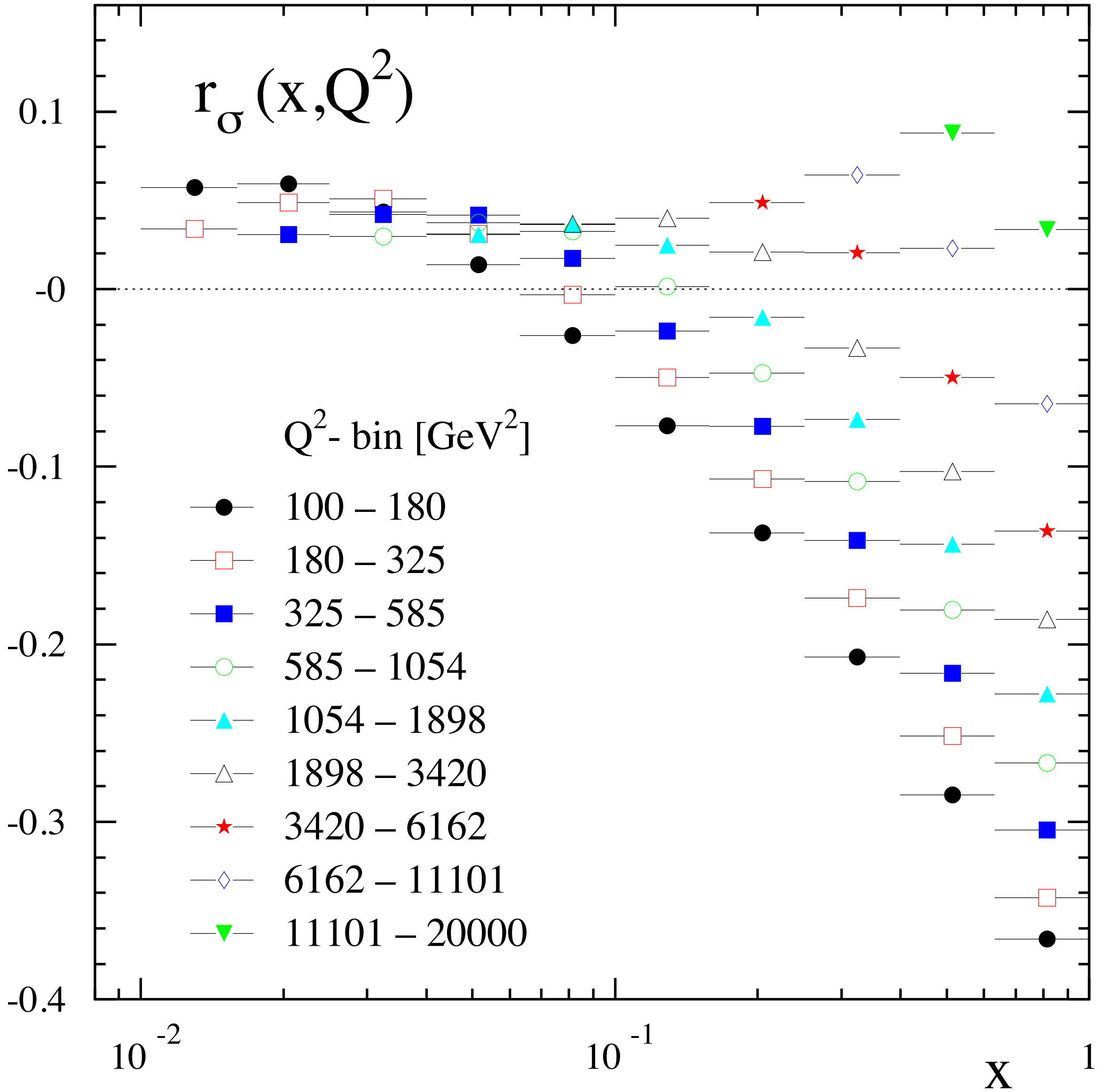
  - LUND string fragmentation: full final state
- Widely used at HERA
- This analysis uses a new version
  - Add **polarised nucleons**

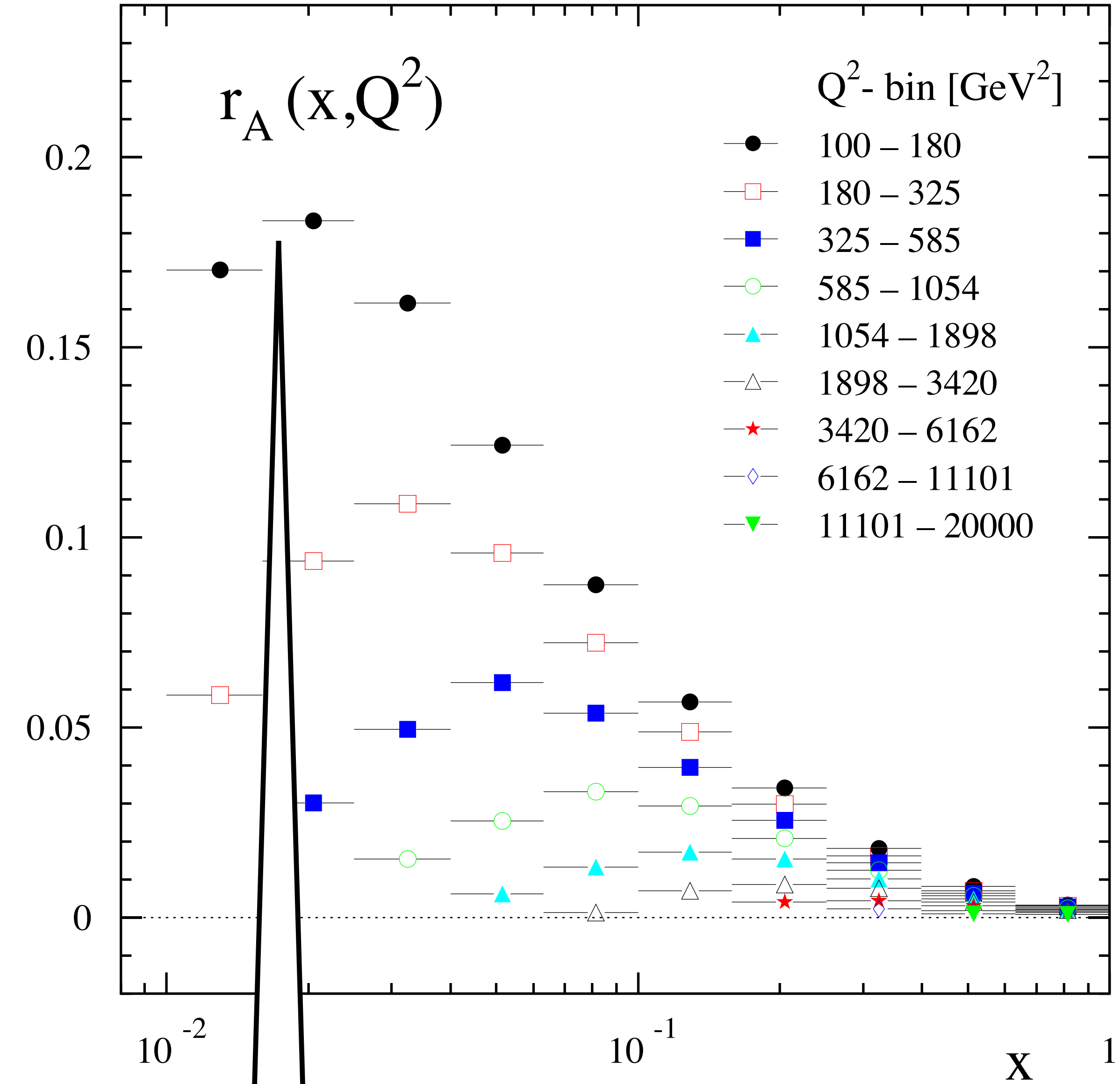
http://wwwthep.physik.uni-mainz.de/~hspiesb/djangoh/djangoh.html

Radiative corrections

$$r_\sigma = d^2\sigma^{W^-,p}|_{\mathcal{O}(\alpha_{em}^3)} / d^2\sigma^{W^-,p}|_{\mathcal{O}(\alpha_{em}^2)} - 1$$

$$r_A = A_L^{W^-,p}|_{\mathcal{O}(\alpha_{em}^3)} / A_L^{W^-,p}|_{\mathcal{O}(\alpha_{em}^2)} - 1$$

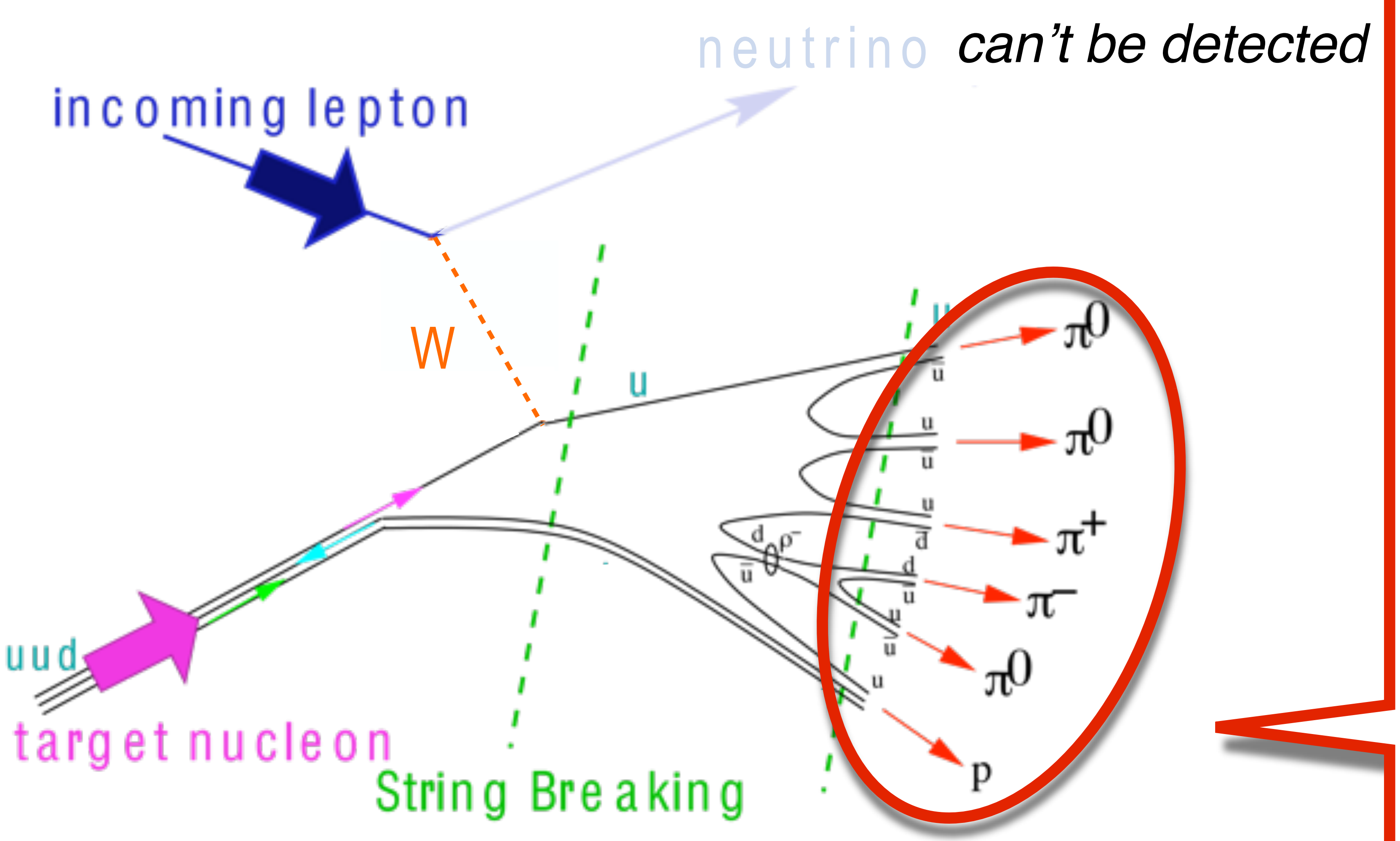




Can expect to be important at **low x** where **A_L^W** is **small**

Detector effects and kinematic reconstruction

Jacquet-Blondel method



Reconstruct kinematics from **hadronic final state**

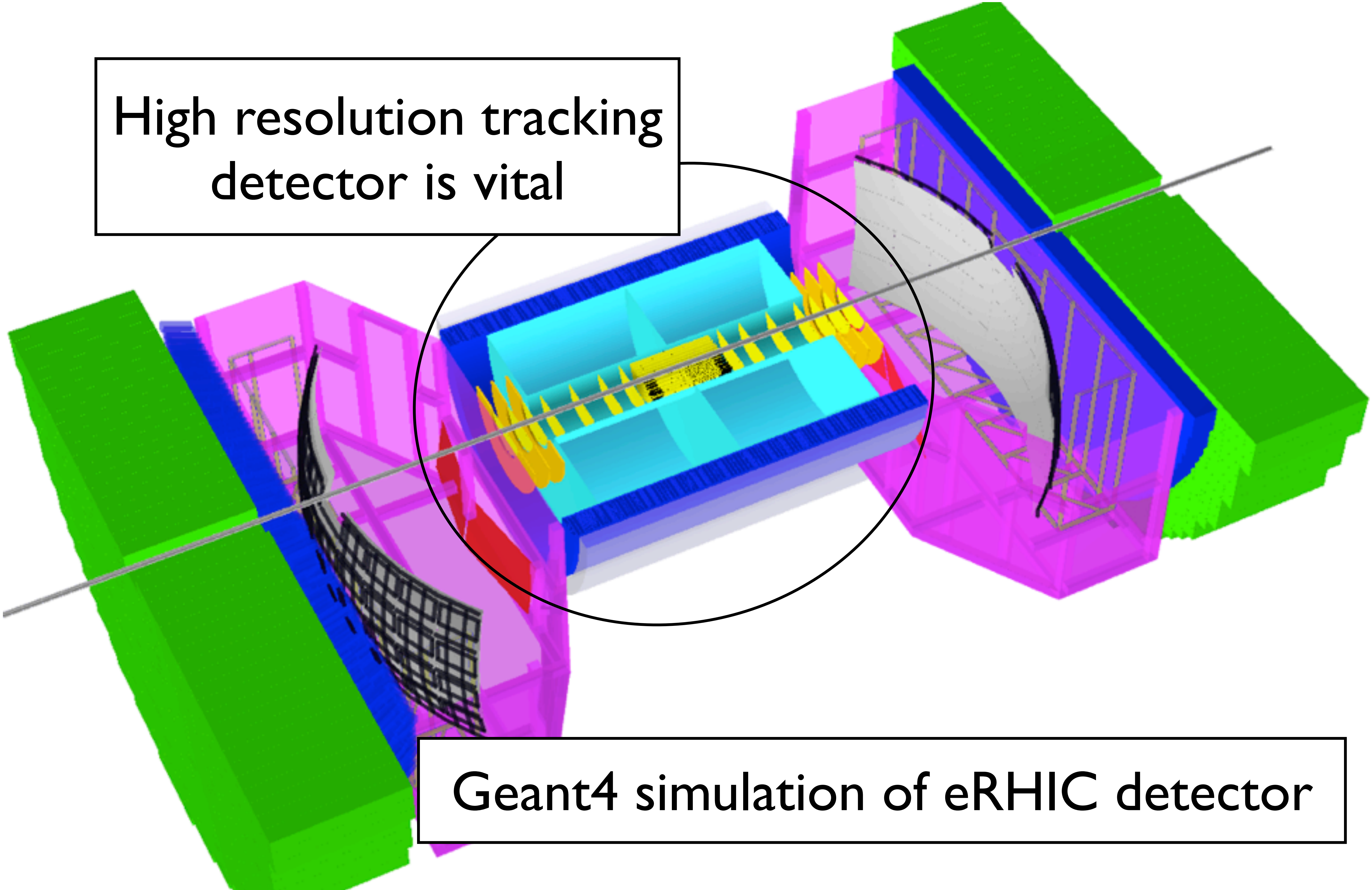
$$y_{\mathrm{JB}} = \frac{\sum_i (E_i - p_{z,i})}{2E_e}$$

$$Q^2_{\mathrm{JB}} = \frac{p^2_{T,h}}{1 - y_{\mathrm{JB}}}$$

$$x_{\mathrm{JB}} = \frac{Q^2_{\mathrm{JB}}}{y_{\mathrm{JB}} S}$$

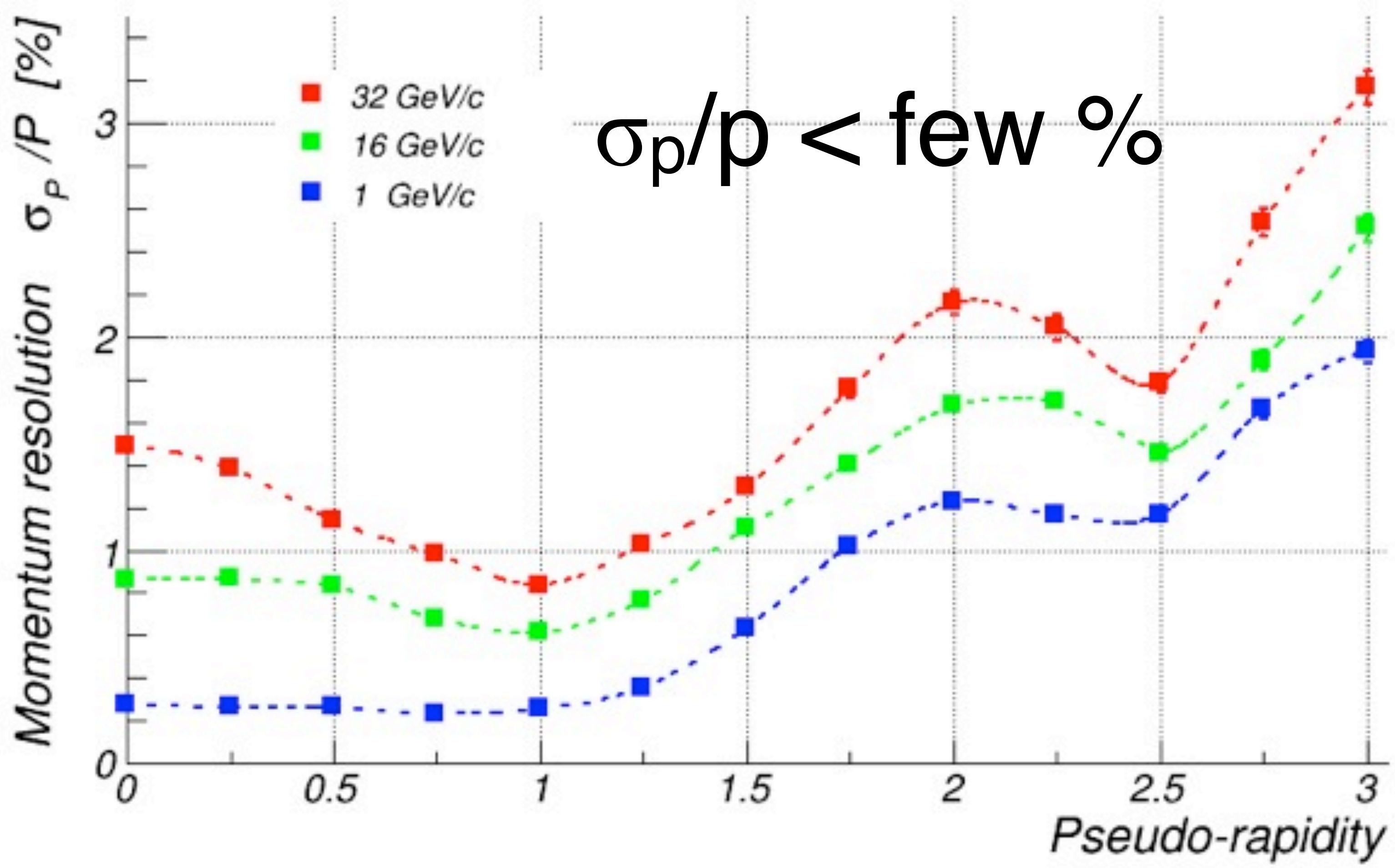
$$\left(p_{T,h} = |\textstyle\sum_i \vec{p}_{T,i}| \right)$$

Requires sufficient detector **resolution** & **acceptance**



eRHIC detector simulation

Detector performance



- ECal: $\sigma_E/E = 12\% / \sqrt{E}$, $-1 < \eta < 4.5$
- ECal: $\sigma_E/E = 1.8\% / \sqrt{E}$, $-4.5 < \eta < -1$
- HCal: $\sigma_E/E = 38\% / \sqrt{E}$, $2 < \eta < 4.5$

Better ECal in electron-going direction

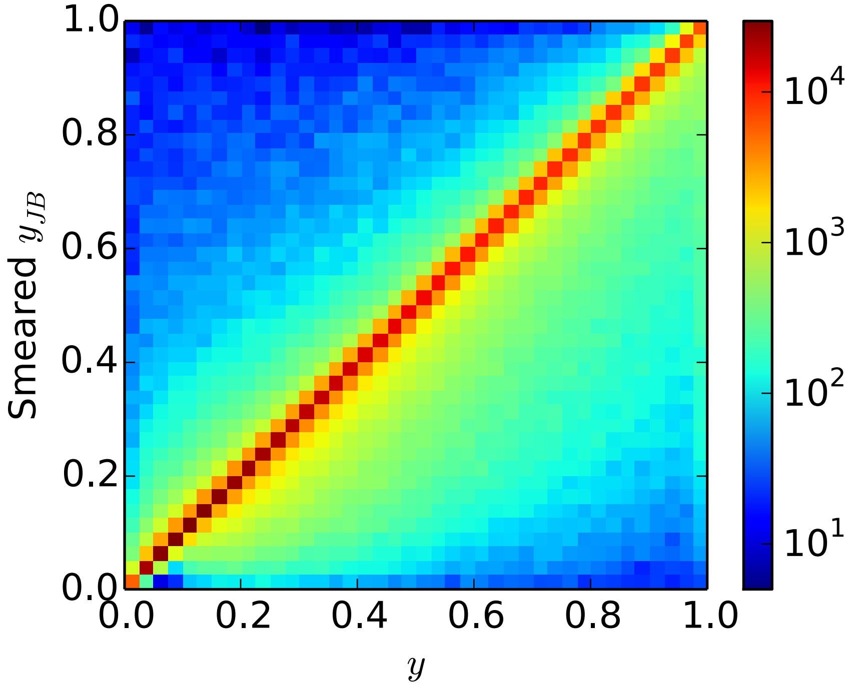
Smear Monte Carlo events with these parameterisations

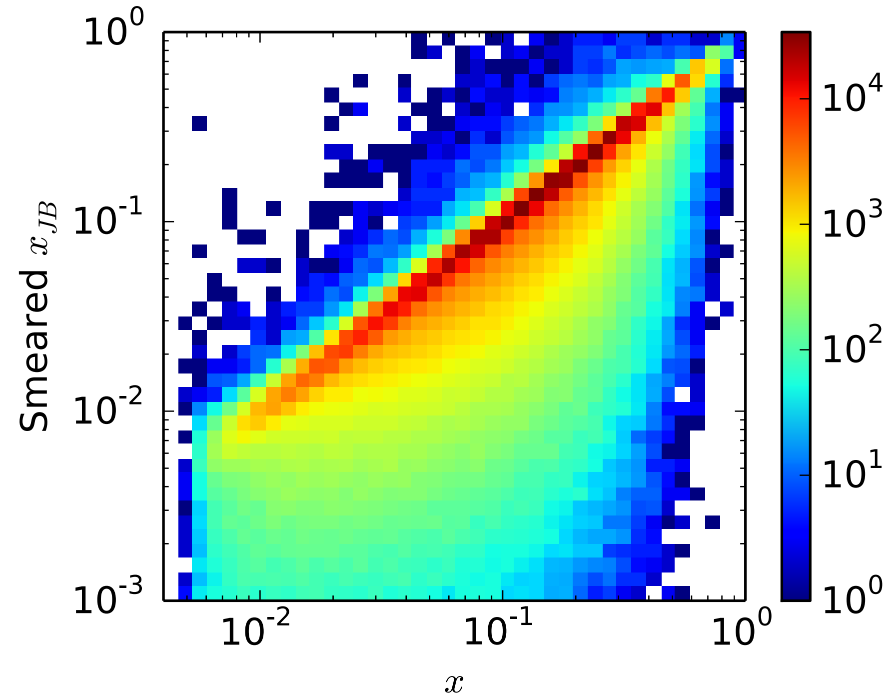
Kinematic reconstruction

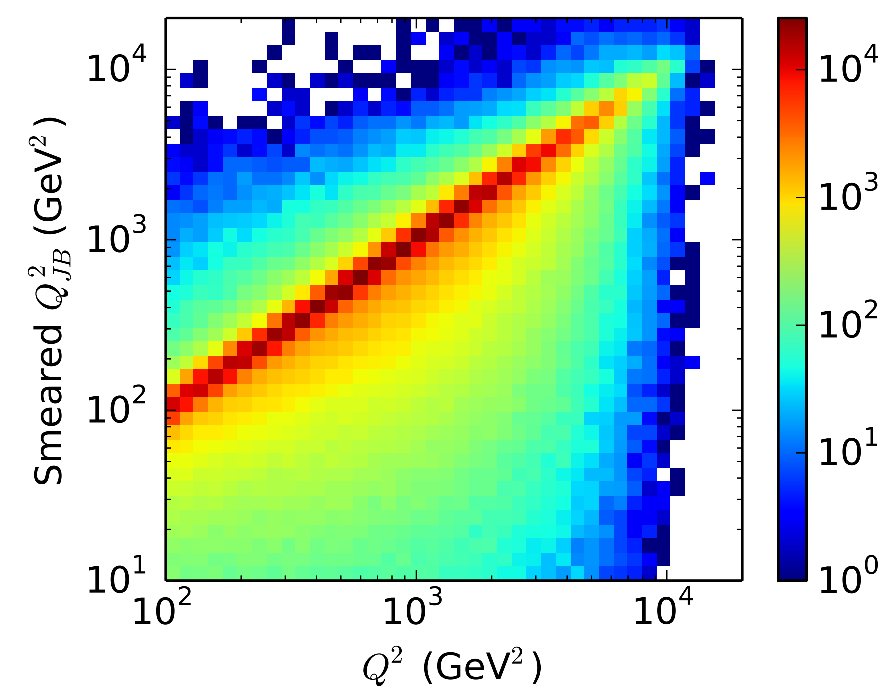
$$y_{\mathrm{JB}} = \frac{\sum_i (E_i - p_{z,i})}{2E_e}$$

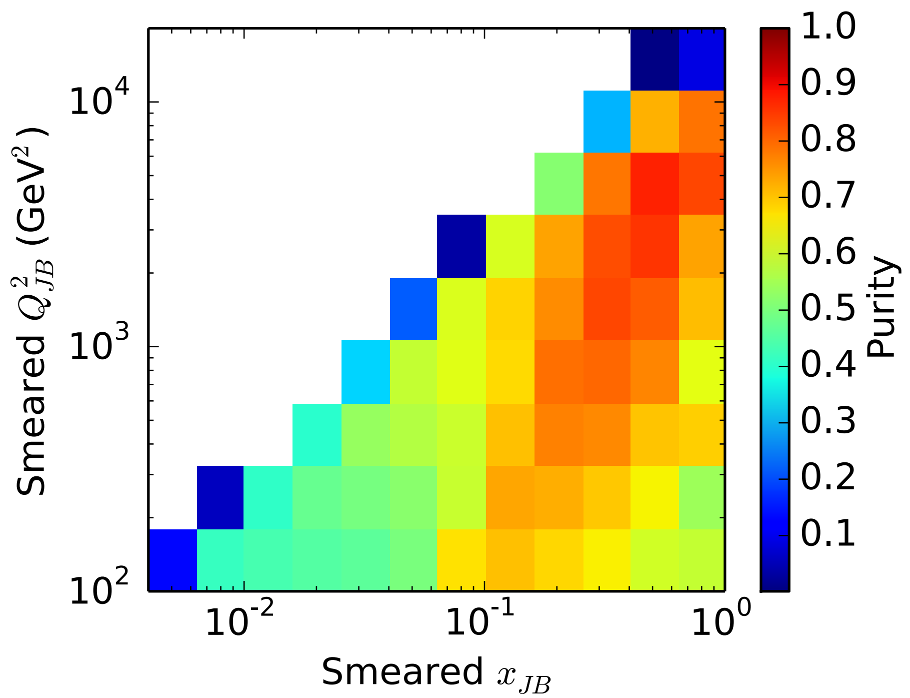
$$x_{\mathrm{JB}} = \frac{Q^2_{\mathrm{JB}}}{y_{\mathrm{JB}} S}$$

$$Q^2_{\mathrm{JB}} = \frac{p^2_{T,h}}{1 - y_{\mathrm{JB}}}, \quad p_{T,h} = |\sum_i \vec{p}_{T,i}|$$







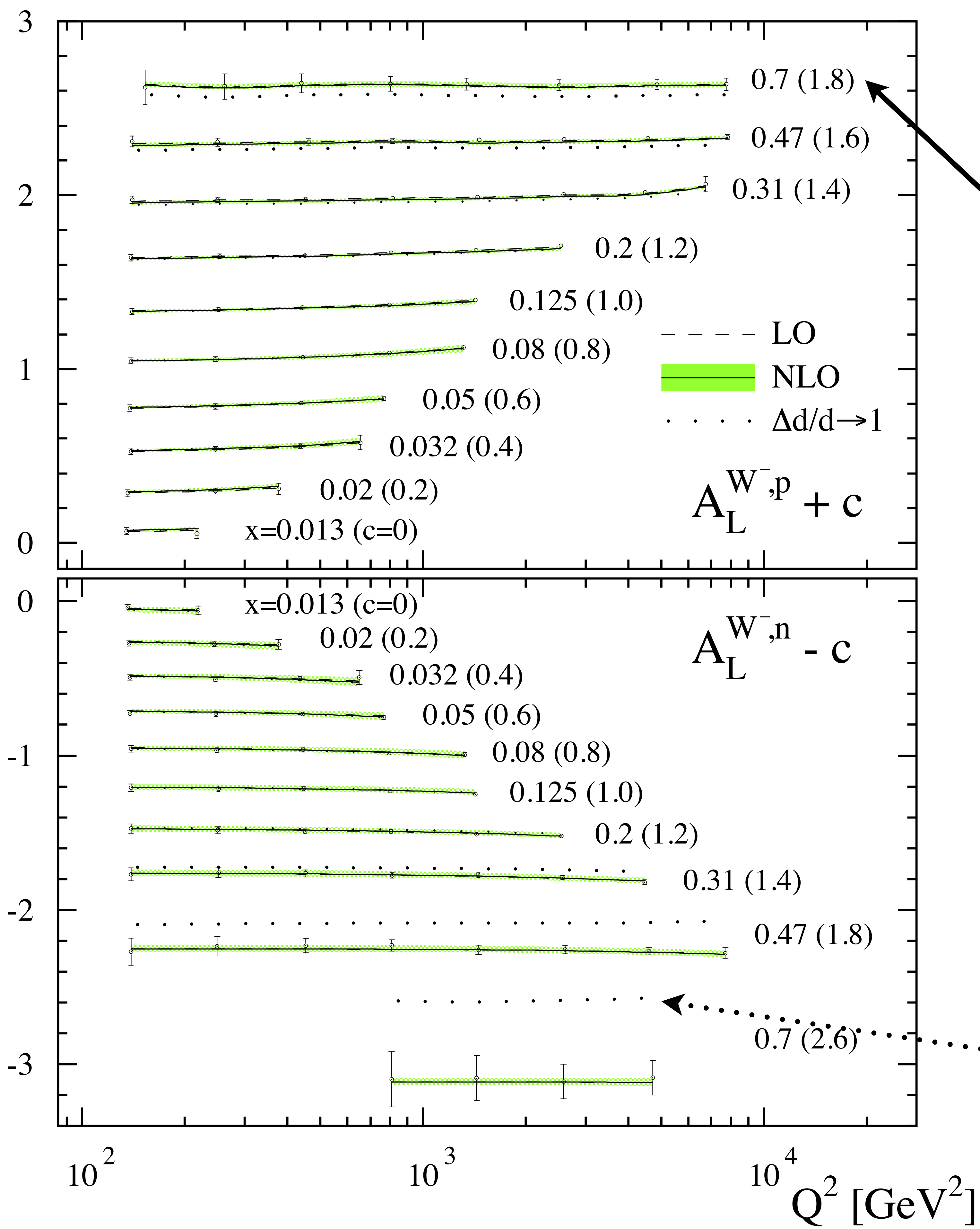


$$\frac{N_{gen} - N_{out}}{N_{gen} - N_{out} + N_{in}}$$

Kinematic construction
under control

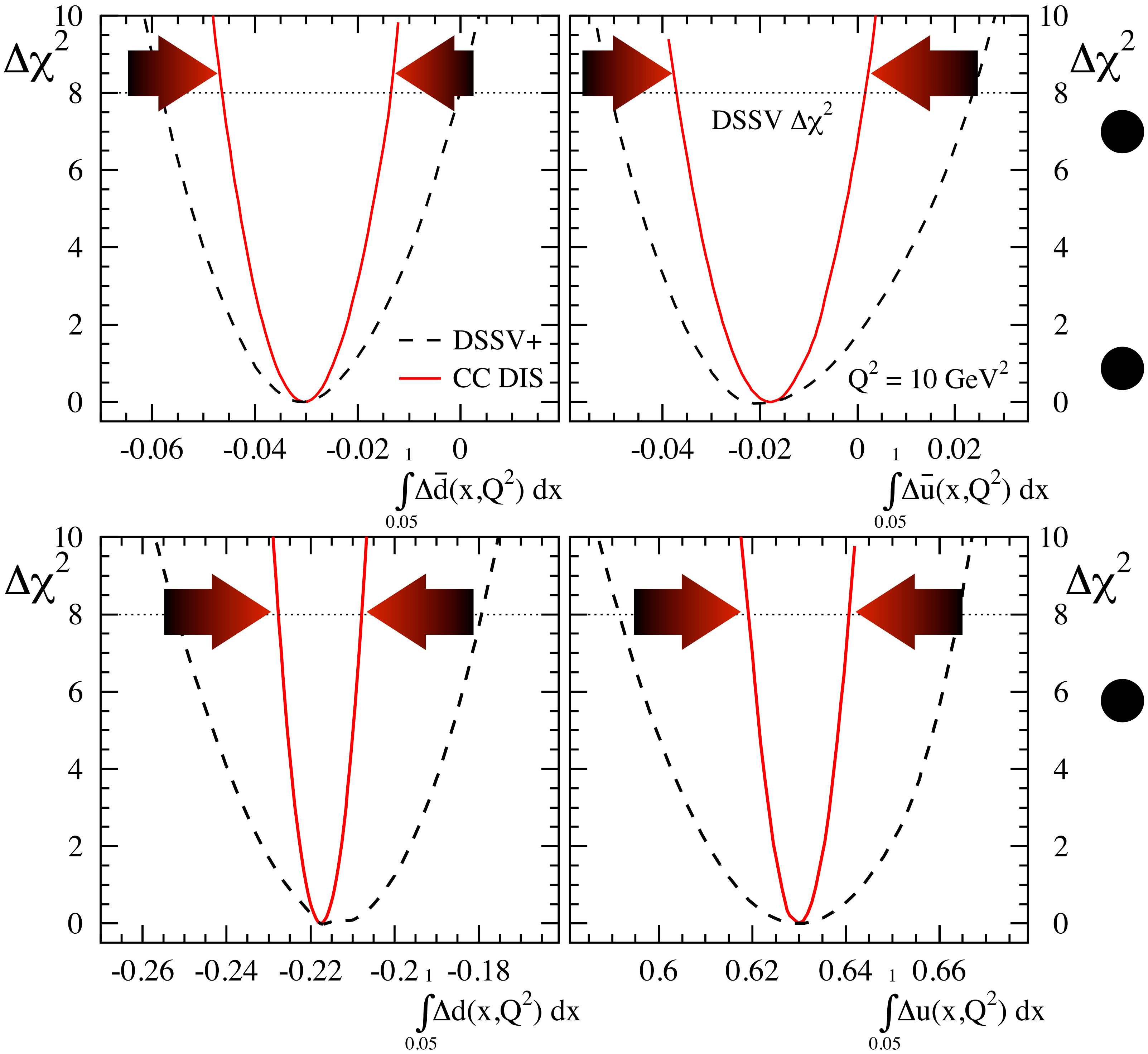
Asymmetry results

A_L^W results



- Large A_L^W at large x ~80%
- NLO effects small
- $\sigma(A_L^W)/A_L^W$ small
  - <~5% for **p**
  - <~8% for **n**
  - ~25% at x limits
- Sensitive to "helicity retention"

Impact on global analyses



- Constrain **u**, **d** & **anti-q** helicities
- Flavour constraint independent of **fragmentation**
- Important cross check on **SIDIS**
  - low Q^2, higher twist effects

Summary

- **Large A_L^W** in CC DIS
  - yields information complementary to SIDIS
- EIC is **ideal laboratory** to study it
  - Proposed detector is **well suited** to the measurement
  - Similar potential for EW transverse spin physics
- Similar studies may give insights into:
  - **Unpolarised PDFs** at high x & high Q^2
  - **Strangeness**, using CC SIDIS with charm